

Outbreaks of *Tomostethus nigrinus* (Fabricius, 1804) (Hymenoptera, Tenthredinidae) on *Fraxinus angustifolia* ‘Raywood’ in Belgium

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Abstract

In Western Europe the ash sawfly *Tomostethus nigrinus* is known to occur at low densities on *Fraxinus excelsior* and is uncommonly reported as a pest species. However, we show here that outbreaks can occur on non-endemic trees such as *F. angustifolia*, and that the species is able to spread quickly using city infrastructure. At the visited localities near the city of Ghent, foliage of *Fraxinus angustifolia* ‘Raywood’ emerged approximately one month earlier than on *F. excelsior*. At the same time, changed climatic conditions in the last decade, i.e. higher temperatures in March, caused adults to emerge earlier. Synchronicity of the potential hosts and *T. nigrinus* may therefore have altered, playing a crucial role in population dynamics. Future research should aim to confirm if the species dramatically declines in numbers after reaching its peak population level, an effect which was observed in previous studies, but for which there is still no satisfactory explanation.

Keywords

sawfly, gregariousness, migration, phenology, ash, urban

Introduction

The ash sawfly, or black sawfly, *Tomostethus nigrinus* (Fabricius, 1804) is widespread throughout the Palaearctic (e.g., Abe 1989 for Japan, Zhelochovtsev and Zinovjev 1996 for Russia, Taeger et al. 2006 for Europe). In the Low Countries it is known to occur at low densities on *Fraxinus excelsior* Linnaeus, 1753. It is considered to be uncommon, only a few observations are known from Belgium and The Netherlands (Bequaert 1912; Crèvecoeur and Maréchal 1938; Magis 1987; pers. comm. A. Mol). Outbreaks were not yet known from those countries. From 2016 onwards however, massive defoliation was increasingly observed in the city of Ghent (Flanders, Belgium) near the ‘Rabotpark’. In 2019 the defoliation event was observed more closely and some specimens were collected. In contrast to many outbreaks explicitly mentioned in the literature, defoliation in Ghent affected *Fraxinus angustifolia* Vahl, 1804 ‘Raywood’, whereas nearby trees of *F. excelsior* were largely ignored.

Based on our observations on this first report of serious outbreaks of *T. nigrinus* in the Low Countries, we want to re-evaluate the importance of host plant specificity. Furthermore we made some interesting observations on both adult and larval behaviour. Finally, we tried to identify possible factors determining and/or controlling the presence and ‘outbreak’ rates of the sawfly larvae.

Material and methods

Voucher specimens

BELGIUM • 1 ♀, 7 mm; Langemark, ‘t Bosseltje; 50°54'57"N, 2°53'31"E; 28 Apr. 2018, F. Verheyde leg.; F. Verheyde coll. 20180428-155545497 • 7♂♂ 2♀♀, 5 larvae; Gent, Rabotpark; 51°03'54"N, 3°43'01"E; 30 Apr. 2019; F. Verheyde leg.; F. Verheyde coll. 20190430-170021621

Apart from the single, previous finding at ‘t Bosseltje (above), which was on *Fraxinus excelsior*, nearly all subsequent observations were made in the city park ‘Rabotpark’, where outbreaks were reported for the first time (coordinates: see above), on *Fraxinus angustifolia* ‘Raywood’. The first author visited the site three times in 2019, on April 11 and 30 and on May 20. The second author, living in the immediate vicinity of the city park, made irregular observations of the ashes from 2016 onwards.

The city park mainly consists of one large avenue and/or bicycle path, with trees planted on both sides of the path. In the surroundings, next to a large building which stands directly before the path, younger trees are planted. Apart from *Fraxinus*, these include *Alnus* and *Robinia* species. Most trees were planted in 2008. In 2012 177 trees of *F. angustifolia* ‘Raywood’ were counted. Common ash or *F. excelsior* is also represented by 7 trees (Roskams and De Haeck 2012).

The adult specimens were identified using Benson (1952). As with most species of the subfamily Blennocampinae, *T. nigrinus* is mainly black, except for its at most piceous front legs. A useful character for recognition of *Tomostethus*, with only one

species in Central Europe, is that vein M of the fore wing runs subparallel with Im-cu. Furthermore, although fore wing vein 2A is reduced, as in other Blennocampinae, this basal part of the fore wing anal cell of *Tomostethus* has a unique shape: sinuately recurved towards vein 1A. The wing membrane has a specific pigmented line in the basal part of the cell, located where 2A is faintly expressed (Fig. 1). The complete wing membranes are more or less greyish, with the fore wings somewhat darker than the hind wings (Benson 1952; Mol 2002). Our collected specimens are mainly males, due to being mainly found on the stems, whereas females fly higher for oviposition. The collected male specimens are on average smaller, varying in body length between 5.5 and 7.0 mm, with females varying between 6.5 and 7.5 mm. Females are slightly more robust than males, with the abdomen and thorax somewhat wider.

Although their association with *T. nigritus* adults seemed obvious, larval determination was checked with Lorenz and Kraus (1957). While morphological details described there are correct, it is important to note that their observations were based on a preserved sample in ethanol from the Natural History Museum, which may explain some errors related to coloration. The larval head for example is without doubt more greenish than yellowish, especially in the first larval instars. In these instars, the abdomen is more brownish coloured and thus contrasts more with the colour of the head (Fig. 2). The older larva becomes a lighter green, with whitish bands (fat bodies) clearly showing through dorsally (Fig. 3). After the last larval moult, the larva changes to an olive green colour just before descending from the tree and prior to spinning its cocoon (Matošević et al. 2003).

Results

During the last week of March and the first two weeks of April 2019 many adults were seen near the ashes. Females were found resting and ovipositing on the edges of the leaves of *Fraxinus angustifolia* (Figs 4, 5). This happened at different heights and on trees of different age. Another part of the city park with approximately 2–3 years old trees was similarly colonized, although the numbers of sawflies were lower. Exceptionally, some (early) males were found feeding on yellow inflorescences of nearby herbs. This was only observed on Brassicaceae, while *Taraxacum* sp., although very abundant, was completely ignored. On most trees a few dozen adults were seen, reaching on an older tree an extrapolated total of approximately 75 adults.

Some other more general behavioural aspects are noteworthy. Firstly, many – especially male – adults were found warming up on the tree stems (Fig. 5). However, some of these adults, both males and females, were also found dead on the stems, still attached with their tarsi to the bark. Secondly, the flying behaviour of the sawfly was found to be quite characteristic and slow, with adults often ‘dropping’ from higher tree branches to the stem. No copulating sawflies were found. Possibly, copulation is brief and takes place higher in the trees. With the favourable weather conditions, the flight period was short, between two and three weeks. From the third week of April onwards, larvae started to hatch.



Figure 1. *Tomostethus nigrinus* F. ♂, leg. Janet Graham, North Wales, V. 2018 Janet Graham.



Figure 2. Younger larva of *Tomostethus nigrinus* on *Fraxinus angustifolia*, leg., det., coll., F. Verheyde, Ghent (BE), 30.IV.2019 Fons Verheyde.

The abundance of larvae made clear how severe the outbreak was. Half a meter around the foot of one tree, in all directions, the ground was covered with a layer of (+ 10.000) larvae, approximately 8 centimetres thick (Figs 6–9). The lowest larvae in this layer, closest to the ground, consisted of some dead or weakened individuals, a couple of them already darkening in colour. However, starvation rates in total seemed



Figure 3. Older larva of *Tomostethus nigrinus* on *Fraxinus angustifolia*, leg., det., coll., F. Verheyde, Ghent (BE), 30.IV.2019 Fons Verheyde.



Figures 4, 5. Adult females of *Tomostethus nigrinus* on *Fraxinus angustifolia*, resting on younger leaves (left); sunning on tree stems (right), Ghent (BE), 11.IV.2019 Fons Verheyde.



Figures 6, 7. Thousands of larvae of *Tomostethus nigritus* on the stem of a tree (left) and a lamppost (right), Ghent (BE), 30.IV.2019 Fons Verheyde.

to be rather low. On another tree, not including the larvae on the ground near the foot, an extrapolated count of 550 larvae was obtained on only the stem (surface size being approximately 2.5 m²). All larval instars were observed, but predominantly the last two instars were found, possibly due to the dates of our visits.

In contrast to normal pupation strategies (Viitasaari 2002), larvae often dropped from the leaves or branches to the ground. Descending larvae on the stems of trees were seldom seen and may in fact be exceptional for some species in outbreaks (e.g. Larsson and Tenow 1984 for *Neodiprion sertifer* Geoffroy, 1785). This finding was confirmed by a citizen who attached five glue bands to a damaged tree in front of his house. The lower bands captured many more larvae. However, the larvae clearly also used this strategy to migrate from tree to tree. Migration happened en masse and in several directions. Near the trees with the most dense population, the bicycle path was coloured green by run over larvae, crossing the path to trees on the other side. Interestingly, larvae ascended everything on their way. A lamppost (Fig. 7), positioned next to the tree with its layer of larvae (Fig. 6), was visited by hundreds of larvae. Similarly visited were a bench, a trash can and a sign post.

The feeding habits of larvae are rather well-described in existing literature, and our observations mostly confirm what is known. The larvae were mainly found on the underside of the leaves (Fig. 11) and only the main veins of the leaves remained after defoliation by the last instars. However, there was a lot of variation in feeding



Figures 8, 9. Layer of larvae (thickness + 8 cm) of *Tomostethus nigrinus* near the base of the stem of *Fraxinus angustifolia*, Ghent (BE), 30.IV.2019 Fons Verheyde.

patterns. The majority of the defoliation, at our study site, started at around 2 to 3 meters above ground level, with the top of the tree only defoliated during a final stage (Fig. 10). However, this was not always the case, and this should be addressed more systematically to make any conclusive remarks. By mid-May, defoliation was complete,



Figures 10, 11. Defoliation of *Fraxinus angustifolia* by *Tomostethus nigrinus*, Ghent (BE), 30.IV.2019 Fons Verheyde.

and just before the end of May most larvae had disappeared. In June no more larvae were found, in contrast to other localities mentioned in literature, where larvae were still active even in the third week of June (e.g. Austara 1991; Stockan and Taylor 2014). Permanent damage appears to be rather limited, which corresponds with the reports in literature (notably Matošević et al. 2003). All ‘damaged’ trees were able to grow new shoots after defoliation.

Distribution

Some efforts were made to find more localities with outbreaks of *T. nigrinus*. The city of Ghent and local entomological associations were contacted. Two additional locations were found using social media. Both, sufficiently documented (and validated), dated from the first week of May and consisted of outbreaks on *Fraxinus angustifolia* ‘Raywood’.

The first location, situated on ‘Sint-Amandsberg’ (Ghent, 51°04'26.4"N, 3°45'36.0"E), is an average city lane, where *Fraxinus angustifolia* ‘Raywood’ is planted on both sides of the road. According to the observer (Wouter Chielens), it was the first time he saw the larvae at this location, having lived there for ten years at the time when he was interviewed. In a direct line, it is 3.1 km distant from the Rabotpark.

The second location, situated in Mariakerke (Ghent, 51°04'20.6"N, 3°41'11.1"E) consists of a square with several trees, five of them representing *Fraxinus* sp. According to

this observer (Kris Van der Stiggel), it was the second year he saw the larvae, but in 2018 they only visited three trees. In a direct line, it is 2.3 km distant from the Rabotpark.

Thirdly, the second author has also seen traces of defoliation on *Fraxinus* sp. near Wondelgem (51°05'13.2"N, 3°42'54.0"E), which is also close to Ghent and Rabotpark (2.3 km). Neither adults nor larvae could be found on this site.

Other smaller and confirmed locations, with at least feeding traces, are a playground near Citadelpark (51°02'16.4"N, 3°43'08.0"E), a playground near Rabotpark (51°03'41.4"N, 3°42'55.1"E) and trees near an intersection (51°04'22.1"N, 3°42'46.8"E). In total, including Rabotpark, seven locations are thus known at the moment, but in fact many more may be found. At the time of writing, the city of Ghent is making an overview of all known locations (pers. comm. Wim Moerdijk, groendienst Stad Gent).

Discussion

The main reason for Ghent being a clear hotspot for the sawfly seems to be nothing more than the choice of *Fraxinus angustifolia* 'Raywood' for amenity tree planting in the city planning. Although we have no clear overview of the total number of trees planted at all locations, it was certainly planted many times between 2005 and 2015 in city parks, streets, squares, etc. The city infrastructure made the quick migration of the sawfly possible. As the species is native, originally it may have spread from the nearest local nature reserves (e.g. Bourgoyen-Ossemeersen, which is only on 2.3 kilometres from the city park). This movement from natural ash 'forests' to plantations is also proposed by Mitali (2012) to explain the dramatic increase of *T. nigritus* in northern Italy. Another possibility is that it was imported with the root balls *Fraxinus*, but no evidence has been found for this, and the fact that trees were planted as early as 2008 speaks against it.

Excluding Italy (Mitali 2012), common ash (*Fraxinus excelsior*) has been mentioned as the most preferred host plant in literature (e.g., Taeger et al. 1998), both for populations at "normal" levels (low densities) or appearing at outbreak levels (high densities). These reports of outbreaks, however, deal with two main types: outbreaks in forests (mainly in eastern Europe), and outbreaks in urban environments (see Tab. 1). Factors influencing outbreak dynamics can be fundamentally different in each case. For example, floods have been identified as an important natural controlling factor in Croatian forests (Matošević et al. 2003).

Parasitism is difficult to assess without rearing, but no parasites were observed in situ. Parasitism rates reported in the literature are however rather high, fluctuating between 44% and 80% (Mrkva 1965; Matošević et al. 2003; Mitali 2012). The rate of predation, e.g. birds feeding on the larvae, is limited. Starlings, wood pigeons and tits were seen eating the larvae, but these were isolated and rare observations. Near London, a pair of blackbirds were seen feeding on the larvae (Cheke and Springate 1999).

Ironically, while our results are opposite (Fig. 12) to the findings of Matošević et al. (2003), who reported severe defoliation of *Fraxinus excelsior*, with *F. angustifolia* nearly untouched, her general hypotheses are confirmed. There is no preference among

Table 1. Reports of outbreaks of *Tomostethus nigrinus* mentioned in the literature.

Location	Date	Host	Environment	Reference
Armenia	?	?	?	Harutyunian (1987)*
Austria				
- Lower Austria: Marchfeld, Waldviertel; Styria: Liezen, Pöls;	1974, 1977, 1999	<i>F. excelsior</i> (and other species?)	Urban: alleys along streets	Pschorn-Walcher (1982)
- Upper Austria: Mühlviertel				Pschorn-Walcher and Altenhofer (2000)
Croatia (Zagreb)	1997	<i>F. excelsior</i>	Urban: streets	Matošević et al. (2003)
Czech Republic	1958–1960	<i>F. excelsior</i>	Forest	Martinek (1964), for southern Moravia
	1965			Mrkva (1965)
	1999–2000	Mixed		Liška and Holuša (2002)
England				
- London	V.1993	<i>F. excelsior</i>	Urban	Cheke and Springate (1999)
- Manchester	2010			Stockan and Taylor (2014)
- Shirley	VI.1952			Benson (1952)
- Telford	2014			
Germany (Lower Saxony)	1993–1994	<i>F. excelsior</i>	Forest	Taeger et al. (1998)
Iran (Kohkilouyeh and Boyer Ahmad province)	?	?	?	Moghadam and Abai (1993)*
Ireland	2016	<i>F. excelsior</i>	Urban	Jess et al. (2017)
Italy				
- Friuli Venezia Giulia	1999–2009	<i>F. angustifolia</i> & <i>excelsior</i>	Urban & forest	Zandigiacomo et al. (2006); Stergulc et al. (2009)
- Lombardia	1980–2007	<i>F. angustifolia</i>	Forest	Trematerra and Petrali (1987); Campanaro et al. (2007)
Norway:				
- Kragerø	1986–1992	<i>F. excelsior</i>	Urban: parks & streets	Fjelddalen (1993)
- Oslo	V–VI.1990			Austara (1991)
- Fredrikstad				
Scotland (Aberdeen)	V-VI. 2013–2014	<i>F. excelsior</i>	Urban: streets	Stockan and Taylor (2014)
Ukraine				
- Donetsk, Kharkov region	2002–2015	Mixed	Urban & forest	Meshkova et al. (2017)
- Molodezhny park of Kharkov	2013–2015			Zinchenko and Kukina (2015)

*- reference not seen.

several ash species, although Pschorn-Walcher (1982) explicitly excluded *F. americana* as a larval host. The most important factor leading to outbreaks is synchrony in the phenology of the insect with that of its potential host plant (Matošević et al. 2003). At the localities we observed, foliage of *Fraxinus angustifolia* ‘Raywood’ emerged approximately one month earlier than on *F. excelsior*. At the same time, changed climatic conditions, i.e. the higher temperatures in March, April and May from 2010 onwards (on average 2 to 3 degrees higher compared to values for 1981–2010; numbers from KMI 2019), caused adults to emerge as early as the last week of March, and larvae were gone before the end of May. Synchronicity of the potential hosts and *T. nigrinus* may therefore have altered. Already Pschorn-Walcher (1982) noted that ash trees growing leaves comparatively early or comparatively late get infested by *T. nigrinus* at a comparatively low rate.



Figure 12. Defoliated *Fraxinus angustifolia* and untouched *Fraxinus excelsior*, Ghent (BE), 15.V.2019 Geert Sioen.

After migrating from a more natural environment, the sawfly might have responded to the different conditions in the urban setting (Matošević et al. 2003). Particularly important may be the absence of flooding, which is thought to cause high mortality in the cocoon stages (e.g. Mrkva 1965). Something which has received little to no interest in the case of *T. nigrinus* are the changes in gregariousness or group living. This is quite surprising in view of the vastly increased density of larvae living together within these urban environments. It was proven for the Australian sawfly *Perga affinis* how important these differences are in the development of the species. For grouped versus single larvae, the mortality risk was found to be lower, growth rates were faster (due to higher temperatures), and individual larvae from large groups had an increased weight in their final instar (Fletcher 2009).

There is one more aspect to consider: the state of health and age of the trees. In the invasive sawfly *Aproceros leucopoda* Takeuchi, 1939 (Argidae), elms are generally infested independent of their age and site characteristics (Blank et al. 2010). However, a severe outbreak was described from eastern Germany, where this species defoliated trees of *Ulmus* 'New Horizon', which were recently planted along a bicycle path (Blank et al. 2014) and supposedly in a physiologically suboptimal state. Meshkova et al. (2017) hypothesized that larger trees tend to be in better health, and although not statistically proven, that defoliation seemingly decreased with tree diameter. Interestingly, our locality, the Rabotpark, used to have many problems concerning the health conditions of its trees, which were planted in 2008. In a report from 2012 the bases

of the stem of 124 Ash trees (67% of the total) were found to be damaged, probably by collisions with mowing machinery. Generally, the condition of the trees planted in the Rabotpark was considered to be moderate to poor. Soil conditions are poor, due to strong soil compaction, disturbed hydrological conditions, large quantities of incorporated fresh organic material, and high salt concentrations. In addition, the ashes were largely planted too deep (Roskams and De Haeck 2012). However, since 2012, the trees have grown and now seem to be relatively healthy. Furthermore, the widespread and undifferentiated distribution of sawfly larvae on trees in and outside the Rabotpark suggests that tree health is not an important factor.

Conclusion

We have shown that in Western Europe urban environments seem to be more suitable places than semi-natural habitats for *Tomostethus nigrinus* to reach a threshold in the numbers of larvae, above which it may be termed as ‘in outbreak’ or as a ‘pest’. Rates of parasitism (and possibly predation) are conceivably lower and environmental conditions (i.e. humidity) influencing the pupal stage are more stable. It is also possible that urban trees are, generally speaking, less healthy due to the soil and mowing conditions in their artificial environment. This may be a trigger to some extent, but should not be exaggerated. More importantly, higher temperatures are reached in cities, and are possibly stimulated by climatological changes. This inspires a faster development of the larvae. As a result, during the last decade the phenology of *F. angustifolia* was able to synchronize with the phenology of *T. nigrinus*. The city infrastructure supported quick migration and an increased density of the species.

When the threshold is reached after which an ‘outbreak’ of *T. nigrinus* occurs, it is possible that the close proximity of many larvae living together brings some the benefits mentioned by Fletcher (2009). From that point onwards, the increased chance of survival and increased fitness of individuals leads to increasing severity of the outbreaks each year until these climax. In the following year the population declines for some yet unknown reason (examples of ‘cycles’ or similar trends can be found in Mitali 2012 and Meshkova et al. 2017). Future research will have to explain this sudden decrease. In our case, it will thus be interesting to see if outbreaks remain equally severe in following years.

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